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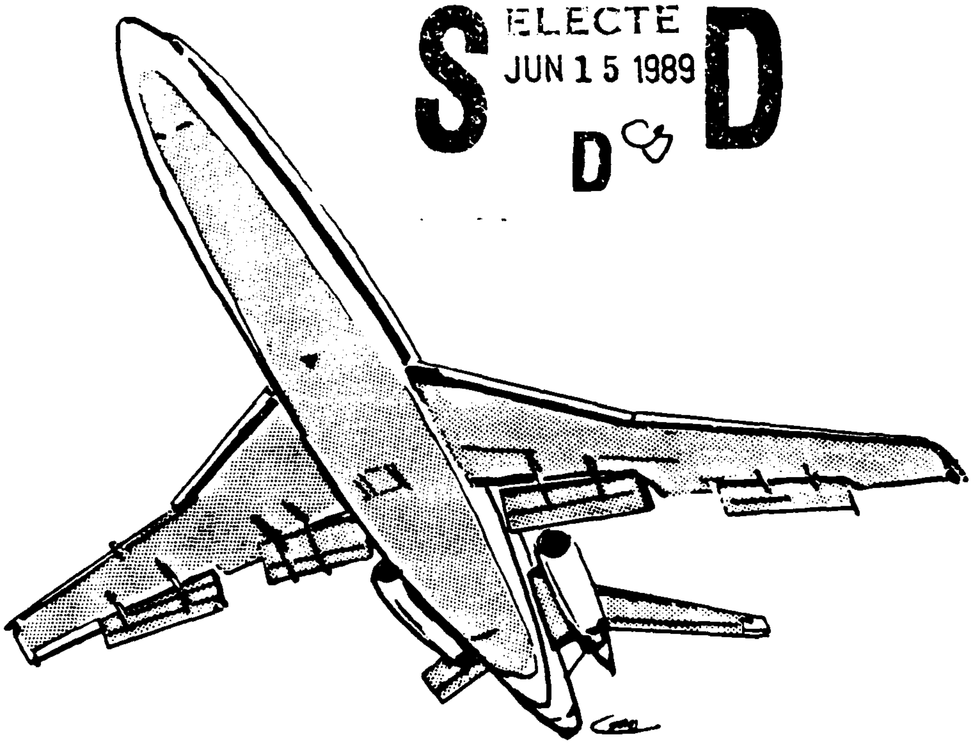
AIRLINE DELAY: 1976 - 1986

Based upon the Standardized Delay Reporting System



March 1989

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U.S. Department of Transportation
Federal Aviation Administration
Office of Aviation Policy and Plans

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EXECUTIVE SUMMARY

Background

This report summarizes delay and delay cost data obtained from the Standardized Delay Reporting System (SDRS) from 1976 through 1986. The SDRS contains reports from three major air carriers: American, Eastern, and United Airlines.

Delay is defined in this report as the difference between the actual and optimal flight times. The optimal time is that required in the absence of other aircraft in the system or problems such as equipment outages or severe weather. Delay is reported for four phases of flight: 1) air traffic control gate hold, 2) delay between gate push back and lift-off (taxi-out delay), 3) delay between lift-off and touchdown (airborne delay), and 4) delay between touchdown and gate arrival (taxi-in delay).

SDRS does not measure delay against scheduled flight times (which anticipate a certain amount of delay) nor does the SDRS report delay due to aircraft mechanical problems and other factors not related to congestion in the airport and airspace system. Thus, statistics in this report may differ from airline performance figures published by the Department of Transportation (DOT), which measure delay against published airline schedules and include delay resulting from other causes. Keywords: Air ...

Major findings are:

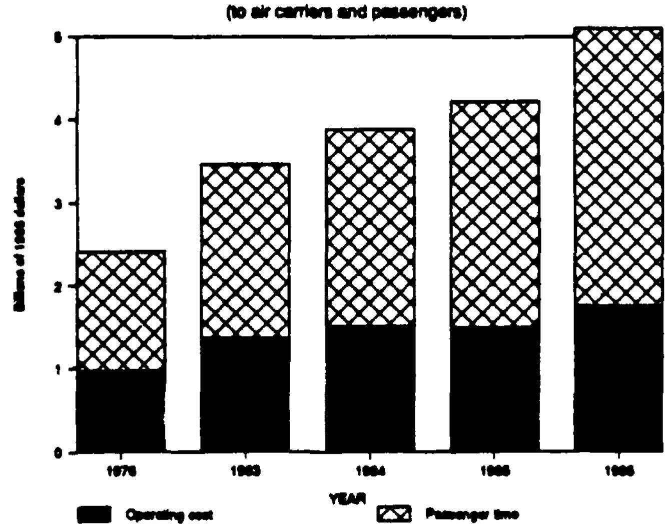
Civil aviation, Air space, Inter- ...

❑ **1. The cost of delay in the National Airway System to air carriers and passengers was estimated to be $5.1 billion in 1986, which is more than double the cost in 1976, in constant dollars.**

It is estimated that total cost of delay to all air carriers and their passengers in 1986 was $5.1 billion ($1.81 billion in operating cost and $3.29 billion in lost passenger time)--compared to $2.4 billion in 1976 (in constant 1986 dollars). This does not include the cost of delay to other airspace users (commuter airlines, general aviation, and military). The increase was due to a 38 percent increase in average delay per flight, a 34 percent increase in the number of air carrier operations, and a 25 percent increase in the number of passengers on each flight. Total airline delay cost increased by 20 percent (in constant dollars) over the previous year.

COST OF AIR CARRIER DELAY

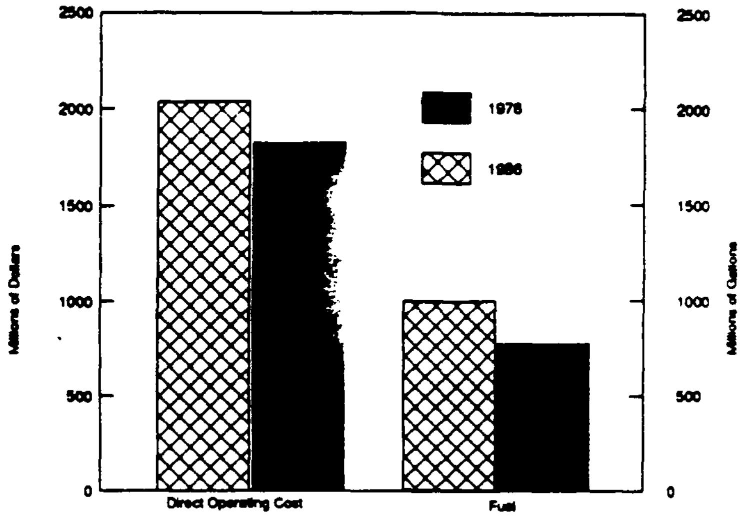
(to air carriers and passengers)



❑ 2. FAA flow control programs saved an estimated $221 million in operating costs (total for all air carriers).

FAA flow control programs hold delayed aircraft on the ground thus reducing operating cost and saving fuel. The use of these programs increased dramatically between 1976 and 1986. In 1976, 39 percent of delay was taken in the air; in 1985 this percentage decreased to 25 percent, and in 1986, it was 24 percent. If the same percentage of delay taken at each phase of flight observed in 1976 had occurred in 1986, it is estimated that delay would have cost all air carriers an additional $221 million in direct operating cost, including the cost of over 200 million gallons of fuel.

AIR CARRIER COST & FUEL CONSUMPTION

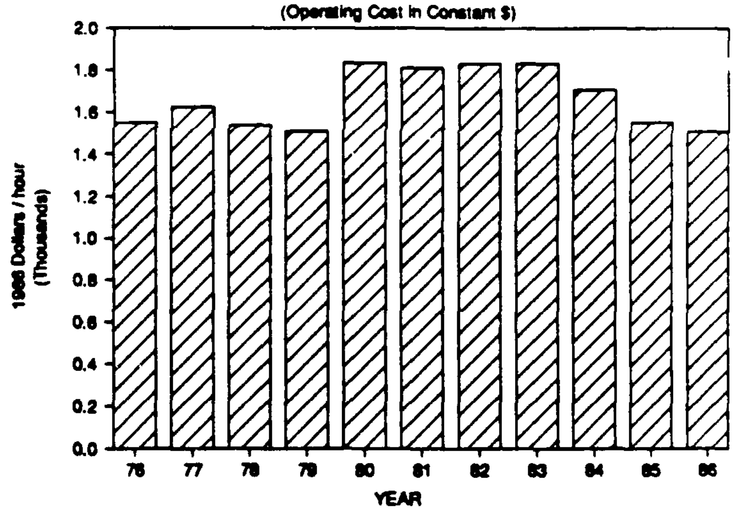


❑ 3. An hour of delay cost the carriers about the same in 1986 as in 1976 (in constant dollars) and consumed less fuel.

In 1986, the average cost of an hour of delay to the reporting carriers was $1,554. This includes the cost of fuel, crew salaries, and direct maintenance. The 1986 average cost for an hour of delay was 0.5 percent more than the cost in 1976 and 2 percent less than 1985, when adjusted for inflation. Fuel consumed per hour of delay decreased from 882 gallons in 1976 to 682 gallons in 1985 and 662 gallons in 1986. These reductions are largely due to the increased use of flow control, without which operating cost would have been $1,744 per hour and fuel consumption 852 gallons per hour in 1986.

DELAY COST PER HOUR TO SDRS CARRIERS

(Operating Cost in Constant $)

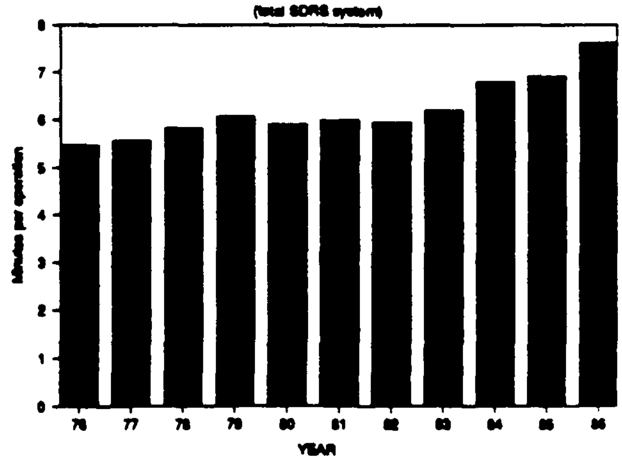


❑ 4. Delay per operation increased 38 percent between 1976 and 1986.

Average delay per operation increased from 5.5 minutes in 1976 to 6.9 minutes in 1985 and to 7.6 minutes in 1986. The 1986 level represents a 38 percent increase over 1976 and a 10 percent increase over the previous year.

AVERAGE DELAY

(total SDRS system)

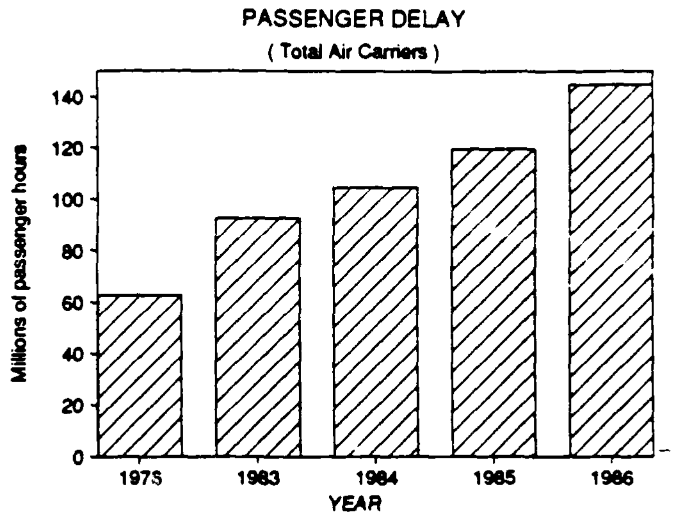


❑ 5. Delay added an average of 15 minutes to each flight (a 20 percent increase) in 1986.

An air carrier flight between two airports consists of two operations (an arrival and a departure). Thus, in 1986, delay added an average of 15 minutes to all domestic air flights, which would have averaged about 65 minutes without delay.

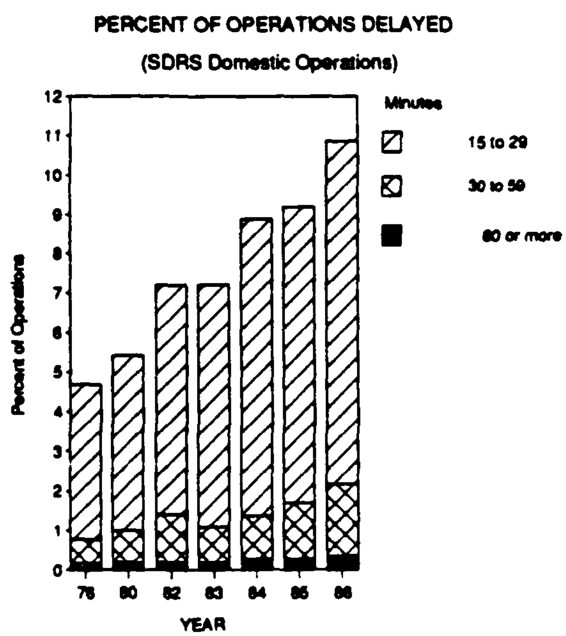
❑ 6. In 1986, an estimated total of 145 million passenger hours were lost due to delay.

Passenger delay for all air carriers totalled 145 million passenger hours in 1986, a 131 percent increase over 1976 and a 21 percent increase over the previous year. These passenger delays include only the delay to passengers on board an aircraft beyond the time that the aircraft reports that it is ready to depart the gate.



❑ 7. The percent of operations delayed 15 minutes or more doubled between 1976 and 1986.

The percent of operations delayed 15 minutes or more increased from 4.7 in 1976 to 9.2 in 1985 and 10.9 in 1986 (increases of 132 percent over 1976 and 18 percent over the previous year, respectively). It should be noted that these figures include only air carrier operations (as contrasted to all operations for the NAPRS data).



Considerations

The purpose of this report is to provide facts and figures on delay and delay cost for the period 1976 thru 1986 which can be used as a framework for further analysis in this area. Care should be taken to fully review and understand the basic definitions used in the development of these data.

In 1987 several measures were taken to control delay: 1) The FAA restructured airspace along the crowded east coast of the United States, 2) the FAA held high-level meetings with the Nation's air carriers to encourage them to reschedule flights where an unreasonable number of aircraft were scheduled to land and takeoff at the same airport simultaneously, and 3) the Office of the Secretary of Transportation began public reporting of scheduled versus actual flight times and imposing penalties to discourage the carriers from publishing unrealistic scheduled flight times. The impact of these changes is not reflected in the data in this report.

This report shows some of the value of the SDRS: 1) it allows an analysis of trends back through 1976, 2) it shows the full spectrum of delay from 1 minute up, 3) it shows where delay occurred, by airport and by four phases of flight, 4) it shows the impact of delay in terms of airline operating cost, fuel consumption, and passenger delay, and 5) it allows analysis of delay patterns on a daily level. SDRS data have been used: 1) as part of the FAA Airport Capacity Enhancement Plan, 2) as input to cost/benefit analyses in support of NAS plan items, 3) to validate delay models, and 4) as input to various studies performed by Government agencies, private industry, and universities.

SECTION 1

INTRODUCTION

PURPOSE

This report contains a summary of delay data obtained through the Standardized Delay Reporting System (SDRS). This system collects data from three major air carriers on delay and the cost impacts of this delay on direct aircraft operating cost, fuel consumption, and passenger delay. Trends in delay and delay costs from 1976 through 1986 are presented, with emphasis on statistics covering 1986.

The SDRS represents the only source of delay data collected continuously over the last 10 years based on a consistent definition and is the only source that measures delay in increments as small as 1 minute. This information has proved useful in estimating potential savings that would be possible from proposed delay reduction measures.

DEFINITION OF DELAY

Delay (or National Airway System (NAS) delay) is defined as the time that it takes to perform a flight from gate-to-gate minus the optimum time that it could have taken in the absence of other aircraft in the system and any NAS problems such as congestion, adverse weather, or NAS equipment failure. Air traffic control (ATC) gate-hold time is included in the delay computation.

By this definition, delay is not measured against schedules. For example, if a flight is delayed due to aircraft equipment problems or is held by the airline for connecting passengers, the flight crew could request permission to depart at a time that is well behind schedule. This delay occurs prior to requesting ATC clearance to push back from the gate and, therefore, is not included in this analysis.

Also, SDRS delay is not accrued if the flight is cancelled. When severe problems such as airport closures occur, this ultimate form of delay goes uncounted.

STANDARDIZED DELAY REPORTING SYSTEM (SDRS)

In 1976 the Office of Aviation Policy and Plans set up a procedure to collect delay data from three major airlines which agreed upon common methods of defining and reporting delay. These data comprise what is referred to as the SDRS.

In the SDRS, daily (or monthly) total delay (to the closest minute) is reported for each airport for each of the following stages of flight:

1. ATC Gate-hold Delay - the difference between the time that departure of an aircraft is authorized by air traffic control and the time that the aircraft would have left the gate area in the absence of an ATC gate hold. (Departures)

2. Taxi-out Delay - the difference between the time of lift-off and the time that the aircraft departed the gate minus a standard taxi-out time established for that type of aircraft and that airline at that airport. (Departures)

3. Airborne Delay - the difference between the time of lift-off from the origin airport and touchdown minus the computer-generated optimum profile flight time for that particular flight based on atmospheric conditions, aircraft loading, etc. (Arrivals)

4. Taxi-in Delay - the difference between touchdown time and gate arrival time minus a standard taxi-in time for that type of aircraft and that airline at that airport. (Arrivals)

The standard taxi times used to compute taxi-in and taxi-out delay were developed by the carriers in 1976 from the lower 10-percentile of the distribution of observed times. They are periodically reviewed and updated by the carriers.

SDRS shows where delay occurs, not where it is caused. For example, delay taken by departing aircraft on the ground could be caused by congestion in the airspace or at the destination airport. Delay in the air could be caused by congestion on the ground at the destination airport. The SDRS does not attempt to assign causes to delay.

OTHER DELAY REPORTING SYSTEMS

The National Airspace Performance System (NAPRS) is a delay reporting system that is maintained by the FAA Air Traffic Operations Service (ATO-100). It is important to differentiate between the two systems. The primary difference lies in the detail of data collected. The NAPRS defines a "delay" as an aircraft flight for which there is a period of 15 minutes or more between a request for permission to taxi and actual takeoff (departure delay), a request for permission to land and actual landing (arrival delay), or a departure delay of 15 minutes or more at an airport because of conditions at a destination airport.

NAPRS does not include cost data, but it does indicate the major causes of the delays. It does not capture every minute of delay, but it does cover all IFR flights, not just those by participating carriers. Because NAPRS relies on air traffic controller observations, the actual gate departure or arrival times cannot be observed at certain airports where aircraft movements are not subject to ATC until they reach the taxiway system.

The Office of the Secretary of Transportation (OST) requires that 14 of the largest carriers provide "performance data" on their flights at 27 of the Nation's largest airports. These data, called "Air Carrier On Time Flight Performance Data," compare actual vs. scheduled arrival and departure times. These data cannot be compared directly to SDRS data because scheduled times anticipate some delay.

This report is based on data from the SDRS only. No comparison of these results with those produced by NAPRS or the OST data is attempted.

SECTION II

ANALYSIS OF DELAY DATA

AVERAGE DELAY

Average delay per operation is the total delay reported in the four phases of flight listed in Section I divided by the total number of reporting takeoffs and landings by the SDRS aircraft. This is a particularly useful measure of delay on an individual airport basis because it can be used to extrapolate the SDRS delay and delay costs to all carriers. Table II-1 shows the level of activity and the average delay per operation for calendar years 1976, 1985, and 1986 at 50 selected airports. Activity declined at nine of these airports between 1976 and 1986 (but at six of these airports, the recent activity trend has been upward). The only airport (of the 32 for which data were available since 1976) at which delay decreased over the period is Kennedy International (JFK). JFK had the largest average delay of all airports in 1976--it had the fourth largest average delay in 1986.

Table II-1 shows that airport operations increased by 19.2 percent between 1976 and 1986, but delay increased by 38.2 percent during the same period.

Figure II-1 presents average delay for each phase of flight for all flights at all domestic airports in the SDRS system during selected years from 1976 through 1986. If the average delay for each phase of flight is summed, the result is the average delay for two operations (an arrival and a departure) which will be referred to as a flight. This is a useful measure of delay for flights between airports. Average delay per flight increased from 11.0 minutes in 1976 to 15.12 minutes in 1986, a 37 percent increase. Average delay grew by 8.5 percent between 1985 and 1986.

When average delay per flight is divided by two, this forms a very good approximation to average delay per operation (7.56 minutes in 1986). It is not exact because there are slightly (0.2 percent) more departures reported than arrivals.

Form 41 reporting carriers flew 8.103 million revenue hours and had 6.177 million revenue departures in scheduled domestic service in 1986.[1/] Thus, the domestic flights averaged 79 minutes from gate-to-gate. Assuming that the SDRS average delay applies to Form 41 reporting carriers in general, 14 minutes of this time was due to NAS delay (the 15-minute average minus 1 minute of gate-hold delay). Thus, delay added an average of 15 minutes to (what should have been) an average 65-minute flight in 1986, a 23 percent increase.

Delay was distributed differently between phases of flight in 1986 than in 1976 (Figure II-1). In 1976 less than 1 percent of delay was taken at the gate (the least costly phase to take delay) and 39 percent was taken in the air (the most costly phase). In 1986, 7 percent of delay was taken at the gate and 24 percent was taken in the air. It is assumed that this

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1/ Based on Form 41 operating statistics for domestic flights in 1986.

TABLE II-1
ACTIVITY AND DELAY AT SELECTED AIRPORTS - 1976 and 1985 vs. 1986

AIRPORT	LOCID	TOTAL AIRPORT OPERATIONS (thousands) 1976	1985	1986	76-86 % inc.	85-86 % inc.	AVERAGE DELAY (mins./op.) 1976	1985	1986	76-86 % inc	85-86 % inc.
ALBUQUERQUE	ABQ	227	232	226	-0.4	-2.7	*	6.7	6.4	*	-3.5
ATLANTA	ATL	490	756	787	60.6	3.9	8.7	8.5	9.1	5.4	7.7
AUSTIN	AUS	165	231	209	26.7	-10.5	*	3.9	4.2	*	6.1
WINSDOR LOCKS	BDL	140	152	163	16.4	6.7	*	5.2	6.1	*	18.3
NASHVILLE	BNA	215	215	252	17.2	14.7	*	4.8	8.0	*	66.6
BOSTON	BOS	307	408	424	38.1	3.8	6.4	8.3	9.0	40.9	8.9
BALTIMORE	BWI	233	283	285	22.3	0.7	4.2	4.6	5.1	22.7	12.1
CHARLESTON	CHS	129	134	137	6.2	2.2	3.7	4.6	4.9	31.9	7.0
CLEVELAND	CLE	235	226	238	1.3	5.0	4.4	5.1	5.1	15.7	-0.5
CINCINNATI	CVG	148	184	183	23.6	-0.5	2.9	3.6	3.9	34.6	8.7
DAYTON	DAY	168	165	194	15.5	14.9	*	5.3	5.9	*	10.6
WASHINGTON NATIONAL	DCA	326	328	326	0.0	-0.6	6.2	6.6	7.7	24.1	16.6
DENVER	DEN	419	495	525	25.3	5.7	6.4	8.7	8.6	34.4	-1.1
DALLAS/FT.WORTH	DFW	360	562	576	60.0	2.4	5.1	8.7	9.6	90.6	10.9
DETROIT	DTW	247	380	413	67.2	8.7	4.0	7.2	6.5	62.0	-10.4
NEWARK	EWR	193	403	414	114.5	2.7	7.5	10.7	11.9	59.2	10.5
HONOLULU	HNL	321	358	368	14.6	2.7	4.6	6.5	7.1	56.0	8.9
DULLES	IAD	188	215	285	51.6	24.6	5.2	5.2	8.1	56.1	55.8
HOUSTON	IAH	208	315	298	43.3	-5.7	4.1	5.0	4.8	16.4	-4.5
INDIANAPOLIS	IND	215	199	209	-2.8	4.8	3.6	4.4	4.5	25.7	2.3
JACKSONVILLE	JAX	128	146	150	17.2	2.7	3.7	4.1	4.5	22.2	9.9
KENNEDY	JFK	332	339	317	-4.5	-6.9	10.5	9.4	9.9	-6.0	5.2
LAS VEGAS	LAS	300	314	365	21.7	14.0	*	4.8	4.4	*	-8.7
LOS ANGELES	LAX	483	546	580	20.1	5.9	4.7	7.3	8.6	83.2	17.3
LAGUARDIA	LGA	345	367	366	6.1	-0.3	9.2	9.8	10.3	11.1	4.4
KANSAS CITY	MCI	179	173	208	16.2	16.8	*	6.4	6.5	*	2.0
ORLANDO	MCO	94	203	220	134.0	7.7	*	4.8	5.2	*	9.6
MEMPHIS	MEM	310	353	382	23.2	7.6	3.3	5.1	5.1	54.5	-0.6
MIAMI	MIA	301	329	351	16.6	6.3	5.2	5.9	7.7	48.2	30.5
MILWAUKEE	MKE	229	188	192	-16.2	2.1	*	4.9	5.3	*	8.2
MINNEAPOLIS	MSP	252	373	400	58.7	6.8	2.7	5.5	6.4	135.5	16.4
NEW ORLEANS	MSY	156	168	169	8.3	0.6	3.0	3.5	3.7	24.3	5.7
OAKLAND	OAK	399	367	388	-2.8	5.4	*	5.8	5.8	*	0.0
ONTARIO	ONT	156	128	134	-14.1	4.5	*	6.3	6.7	*	6.3
CHICAGO	ORD	718	770	794	10.6	3.0	9.0	9.0	10.8	20.1	19.4
PALM BEACH	PBI	220	225	225	2.3	0.0	*	5.3	5.5	*	4.1
PORTLAND	PDX	217	219	224	3.2	2.2	*	4.6	4.9	*	6.5
PHILADELPHIA	PHL	311	354	378	21.5	6.3	6.8	5.5	7.0	2.1	27.3
PHOENIX	PHX	425	398	417	-1.9	4.6	3.4	5.7	5.9	72.2	3.2
PITTSBURGH	PIT	310	363	366	18.1	0.8	5.4	6.0	5.9	11.0	-1.7
RALEIGH/DURHAM	RDU	198	209	210	6.1	0.5	3.5	4.7	4.9	40.1	4.3
SAN DIEGO	SAN	207	162	170	-17.9	4.7	*	5.7	5.9	*	3.5
SAN ANTONIO	SAT	195	207	199	2.1	-4.0	*	4.5	5.2	*	15.9
SEATTLE	SEA	174	236	260	49.4	9.2	3.7	4.6	5.0	35.5	8.7
SAN FRANCISCO	SFO	343	399	430	25.4	7.2	5.3	8.5	9.3	73.8	8.7
SAN JOSE	SJC	470	366	351	-25.3	-4.3	*	7.0	7.1	*	1.4
SALT LAKE CITY	SLC	255	258	277	8.6	6.9	*	6.1	6.1	*	0.0
SACRAMENTO	SMF	140	137	161	15.0	14.9	*	3.7	4.0	*	8.1
ST.LOUIS	STL	321	428	458	42.7	6.6	4.7	6.9	7.9	69.0	14.5
TAMPA	TPA	192	268	253	31.8	-5.9	3.7	4.1	4.5	21.1	9.0
TOTAL		13427	15323	16012	19.2	4.5	5.5	6.9	7.6	38.2	10.1

* DATA NOT AVAILABLE

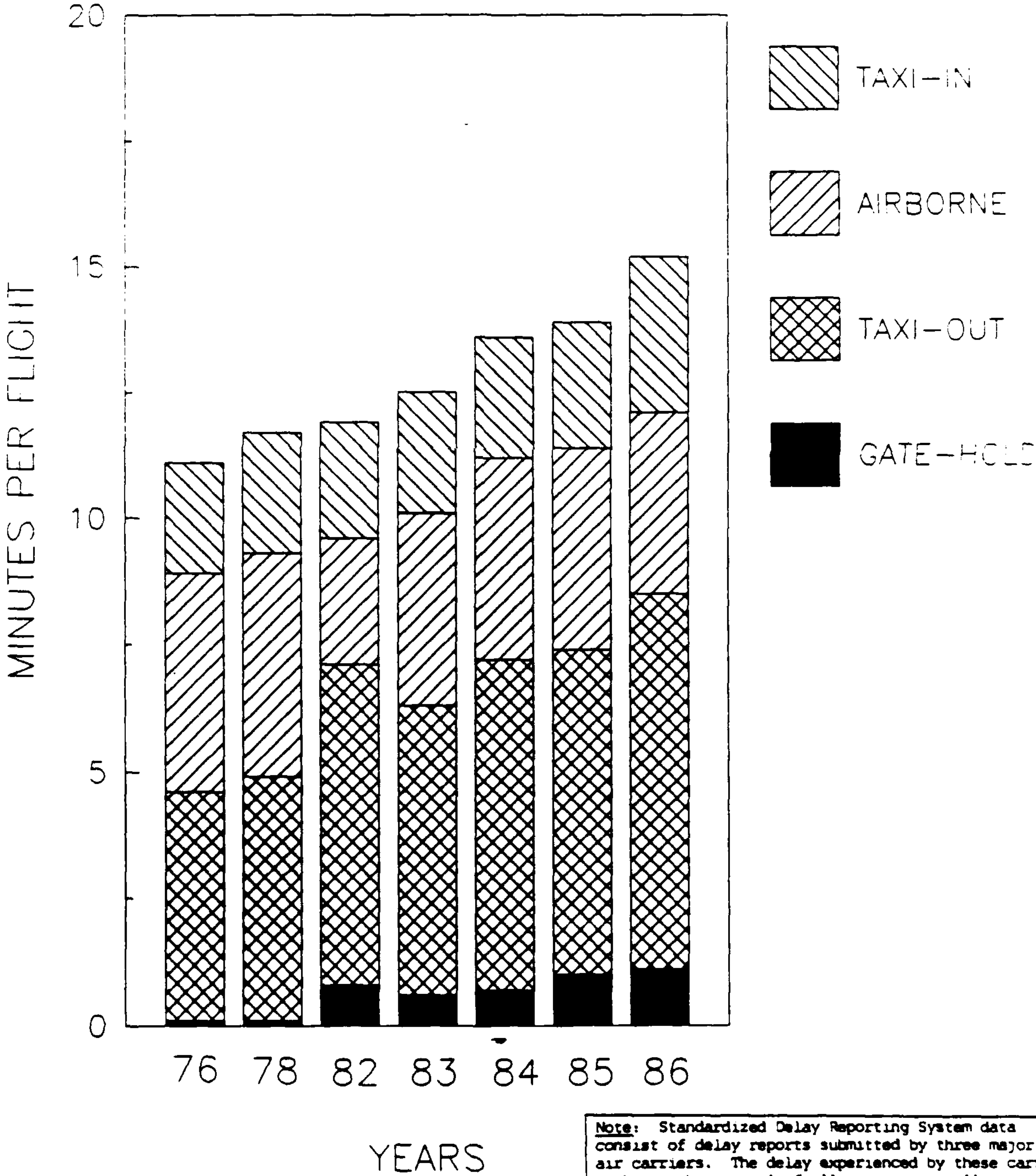
SOURCE: Operations - Office of Management Systems
Delay - Standardized Delay Reporting System

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

FIGURE II-1

AVERAGE DELAY BY PHASE OF FLIGHT

(Total SDRS System)



<u>Note</u>: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

change reflects a greatly expanded FAA flow control program whereby when serious delay is anticipated, aircraft are held on the ground rather than in airborne holding patterns.

The distribution of delay by phase of flight varies considerably between airports. Table II-2 shows average delay by phase of flight for 50 selected airports. For example, at ATL, departure operations were delayed 0.6 minutes at the gate and 8.7 minutes during taxi-out, and arrival operations were delayed 6.3 minutes in the air and 2.6 minutes during taxi-in, on average. The overall delay average per operation (arrivals and departures combined) is approximately the total for both operations combined divided by two, which is 9.1 minutes.

Average taxi-in delay varies from 0.8 minutes per operation at Las Vegas (LAS) to 6.6 minutes per operation at Chicago O'Hare International (ORD), while average taxi-out delay ranges from 2.8 minutes per operation at Covington/Greater Cincinnati International (CVG) to 13.2 minutes at LaGuardia (LGA). Thus, taxi-out delay has almost twice the variation as taxi-in delay. Taxi-in delay is usually caused by congestion on the local airport surface only, while taxi-out delay can also be caused by congestion at the destination airports and the resulting delay is passed on by flow control procedures.

SDRS PERCENT OF SCHEDULED OPERATIONS

SDRS data do not represent a random sample of airline flights. These data reflect the scheduling of flights adopted by three participating carriers in their attempt to find their own niche in the market. Thus, the share of scheduled operations they perform varies greatly between airports. Also, the percent of the total operations performed by SDRS carriers at each airport each hour varies greatly. Although the SDRS delay figures could be larger or smaller than the true average at any given airport, they are unique in that they represent a data base that goes back to 1976 with consistent methodology and the same reporting entities.

The right-hand section of Table II-2 compares the number of SDRS operations as a percent of total at the selected airports. The first column in this section shows the percent of all scheduled operations performed by the SDRS carriers (based on a May 1986 weekday schedule). This includes air carrier and commuter airlines, but not scheduled air cargo operations. Operations by code sharing carriers affiliated with the SDRS carriers are included in the total, but are not counted as SDRS operations because they are not reported in the SDRS data. The SDRS share of all scheduled operations varies between 4.4 percent at Memphis International (MEM) to 55.5 percent at ORD. The overall average is 23.1 percent for the 50 airports.

The second column shows the percent of the operations in the three busiest hours that are scheduled by the SDRS carriers. (The 3 hours were selected for each airport based on total operations scheduled during the hour.) Comparison of the first and second columns shows that at most airports the SDRS share during the peak hours is approximately equal to the SDRS share for the day, which implies (for airports for which this is the case) that the SDRS carriers schedule approximately the same percent of their operations during the peak periods as the other carriers.

TABLE II-2

AVERAGE DELAY BY PHASE OF FLIGHT AT SELECTED AIRPORTS AND SDRS PERCENT OF ALL SCHEDULED OPERATIONS - 1986

	AVERAGE DELAY (In Minutes per Operation)					SDRS Pct. of Schdl.	
LOCID	Gate-hold	Taxi-out	Airborne	Taxi-in	Overall	Daily	Peak hrs.
ABQ	0.7	6.6	2.2	3.4	6.4	12.6	16.9
ATL	0.6	8.7	6.3	2.6	9.1	36.5	38.4
AUS	0.7	3.5	2.7	1.4	4.2	19.9	26.9
BDL	1.3	6.5	2.6	1.9	6.1	21.2	18.2
BNA	1.2	7.5	5.3	2.0	8.0	37.6	47.0
BOS	2.9	7.9	4.4	2.8	9.0	15.6	11.3
BWI	1.6	5.2	2.5	1.0	5.1	12.0	10.8
CLE	1.7	4.3	2.3	1.7	5.1	30.3	30.3
CMH	1.4	4.5	2.3	2.1	5.2	22.5	22.5
CVG	1.0	2.8	2.8	1.2	3.9	8.4	7.6
DAY	2.0	5.3	2.1	2.4	5.9	5.4	2.1
DCA	1.3	9.5	2.8	1.7	7.7	24.1	24.1
DEN	0.4	10.2	2.9	3.6	8.6	35.4	32.3
DFW	0.5	7.5	5.3	6.0	9.6	44.5	46.7
DTW	1.4	5.6	3.9	2.3	6.5	9.2	9.9
EWR	3.8	11.1	6.0	2.9	11.9	13.1	11.9
HNL	0.5	8.0	3.5	2.2	7.1	8.4	9.0
IAD	1.3	9.1	2.7	3.1	8.1	30.6	24.0
IAH	1.0	3.9	2.2	2.4	4.8	17.0	11.9
IND	1.5	3.4	2.6	1.5	4.5	17.8	24.2
JAX	1.5	3.9	1.8	1.8	4.5	23.6	14.1
JFK	1.0	10.6	4.3	3.9	9.9	18.8	14.3
LAS	1.0	4.4	2.6	0.8	4.4	17.6	12.5
LAX	2.3	8.2	3.7	3.1	8.6	17.2	14.6
LGA	1.0	13.2	3.7	2.6	10.3	30.3	29.0
MCI	2.7	6.0	2.1	2.2	6.5	31.6	35.9
MCO	1.4	5.2	1.6	1.6	5.2	20.5	19.9
MEM	0.9	5.1	2.7	1.9	5.1	4.4	2.2
MIA	1.8	9.0	2.7	2.0	7.7	27.4	29.1
MKE	1.2	5.3	2.4	1.8	5.3	13.6	11.1
MSP	2.1	5.2	4.0	1.5	6.4	5.2	4.4
MSY	1.0	3.7	1.7	1.1	3.7	17.0	13.9
OAK	1.4	5.0	3.3	2.1	5.8	14.8	6.2
ONT	1.8	7.4	2.9	1.3	6.7	22.8	24.8
ORD	0.4	10.2	4.4	6.6	10.8	55.5	52.3
PBI	1.7	6.2	1.7	1.4	5.5	15.4	11.1
PDX	1.0	4.5	2.8	1.5	4.9	21.5	22.2
PHL	1.3	6.6	4.3	1.7	7.0	17.0	11.4
PHX	1.2	5.8	2.6	2.2	5.9	10.7	7.9
PIT	1.9	5.6	2.5	1.9	5.9	6.6	4.5
RDU	1.7	4.3	2.0	1.8	4.9	26.3	27.4
SAN	1.4	6.2	3.2	1.0	5.9	18.8	21.0
SAT	0.8	5.2	3.3	1.6	5.2	20.6	30.9
SEA	1.9	4.6	2.9	1.7	5.0	19.7	19.8
SFO	1.8	9.7	3.8	3.3	9.3	31.9	41.0
SJC	1.5	6.9	3.4	2.4	7.1	14.2	15.5
SLC	1.1	6.9	2.3	1.9	6.1	9.5	1.6
SMF	1.0	3.6	2.1	1.4	4.0	14.8	11.2
STL	1.5	8.2	4.5	1.6	7.9	4.7	4.2
TPA	0.9	4.5	2.1	1.5	4.5	24.2	23.9
Total	1.1	7.4	3.6	3.1	7.6	23.1	21.7

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

SOURCE: Standardized Delay Reporting System

NOTES:

1. Shows where delay occurred, not where caused.
2. "Total" represents the average for all domestic airports.
3. "Daily" shows percent of scheduled operations (air carrier and commuter) performed by SDRS (reporting) carriers (weekdays) in May 1986.
4. "Peak Hours" is the percent of scheduled operations performed by SDRS carriers during the busiest 3 hours of the day.

The overall average of 23.1 percent for the day compared to 21.7 percent for the peak periods shows that SDRS schedule peaking is almost identical to that of all carriers for the 50 airports as a whole.

DELAY BY DAY

SDRS reports delay on a daily basis, at each airport served, by phase of flight. The following discussion shows a sample of these data and how they can be analyzed.

As evidenced in Table II-3, average delay can vary considerably from one day to another. (This table is based on data for April 1986 only, but similar results would result from analysis of other months.) The variation is greater at some airports than at others. Of the 42 airports listed, the airport that experienced the most pronounced variability (the largest standard deviation) was Dallas/Ft. Worth International (DFW). DFW also had the highest average delay for the month and the highest 1 day average (56.4 minutes per operation). (This occurred on April 19 when 100 out of 275 SDRS arrivals were delayed an hour or more on during taxi-in.)

The three major New York City area airports (EWR, JFK, and LGA) and Boston International (BOS) also had high variability as well as days when average delay exceeded 20 minutes per operation. Incidentally, different airports experienced peak average delay on different days.[1/]

Figure II-2 shows the average delay in the four phases of flight each day at Atlanta International (ATL) during the month of April 1986. Average delay on the worst day (April 8) was 13.1 minutes per operation, which was more than double that on the best day (April 19) when the average was 5.9 minutes. Taxi-in delay is fairly constant from day-to-day, but taxi-out and airborne delay (both of which are very weather dependent[2/]) can vary dramatically. ATL ranked eleventh in variation in average delay of those airports listed in Table II-3.

DISTRIBUTION OF DELAY

Averages alone do not tell the whole story. The SDRS also contains data on the distribution of delay duration. Table II-4 shows the percent of flights delayed by length of delay for each phase of flight for 1986. For example, 93.4 percent of all flights had no ATC gate-hold delay, 4.1 percent were delayed 1-14 minutes, 1.5 percent were delayed 15-29 minutes, and 0.3 percent were delayed an hour or more at the gate.

1/ The worst days had one thing in common, bad weather. According to NAS Performance Reports (prepared by ATO-102), weather conditions on the record days included extremely poor visibility, rain, strong winds, or all of the above. On April 19, DFW experienced severe thunderstorms.

2/ The NAS Performance Reports show that on April 8, 20, and 21 there were thunderstorms at Atlanta. On April 8, the New York City area, Boston, and Philadelphia also had thunderstorms and on April 20, there were weather problems at St. Louis, Minneapolis, and Chicago.

TABLE II-3

VARIATION IN AVERAGE DELAY BY DAY - APRIL 1986

	Average Delay (minutes/operation)			
LOCID	Month	Min. Day	Max. Day	Std. Dev.
ATL	7.9	5.9	13.1	2.0
BDL	6.7	3.7	13.5	2.2
BOS	9.5	4.3	20.9	3.9
BWI	5.1	2.5	8.4	1.3
CLE	4.5	3.0	6.7	0.9
CMH	6.5	4.6	8.7	1.1
CVG	3.5	2.2	6.1	0.9
DCA	7.4	3.6	18.2	3.4
DEN	9.5	5.8	17.7	2.7
DFW	12.6	8.9	56.4	8.5
DTW	6.3	4.2	9.4	1.3
EWR	10.8	6.5	26.6	3.9
HNL	7.8	5.2	11.8	1.4
IAD	7.0	4.7	13.3	1.8
IAH	4.7	3.2	11.7	1.6
IND	3.7	2.2	6.2	0.8
JAX	4.7	3.6	6.4	0.7
JFK	11.3	6.1	23.8	3.7
LAS	3.4	2.0	6.2	1.2
LAX	8.7	6.5	12.6	1.4
LGA	10.1	4.9	20.8	3.9
MCI	6.2	4.3	9.8	1.4
MCO	6.3	4.1	10.3	1.2
MEM	5.0	2.9	11.3	1.6
MIA	7.0	6.1	8.6	0.6
MSP	6.0	4.2	10.7	1.6
MSY	4.2	2.8	8.4	1.2
OAK	6.8	4.5	9.1	1.3
ONT	5.7	3.9	8.3	1.1
ORD	9.5	6.8	19.5	2.5
PDX	4.5	2.9	7.4	0.9
PHL	6.8	3.9	15.5	2.6
PHX	5.6	4.6	7.4	0.6
PIT	5.2	2.9	9.9	1.4
RDU	4.7	3.3	7.3	0.8
SAN	4.1	2.5	6.2	0.9
SEA	4.7	3.6	6.4	0.7
SFO	9.0	7.1	14.5	1.6
SJC	7.0	4.6	10.9	1.7
SMF	4.0	2.7	6.0	0.8
STL	7.0	5.1	13.2	1.5
TPA	4.4	3.3	6.1	0.7

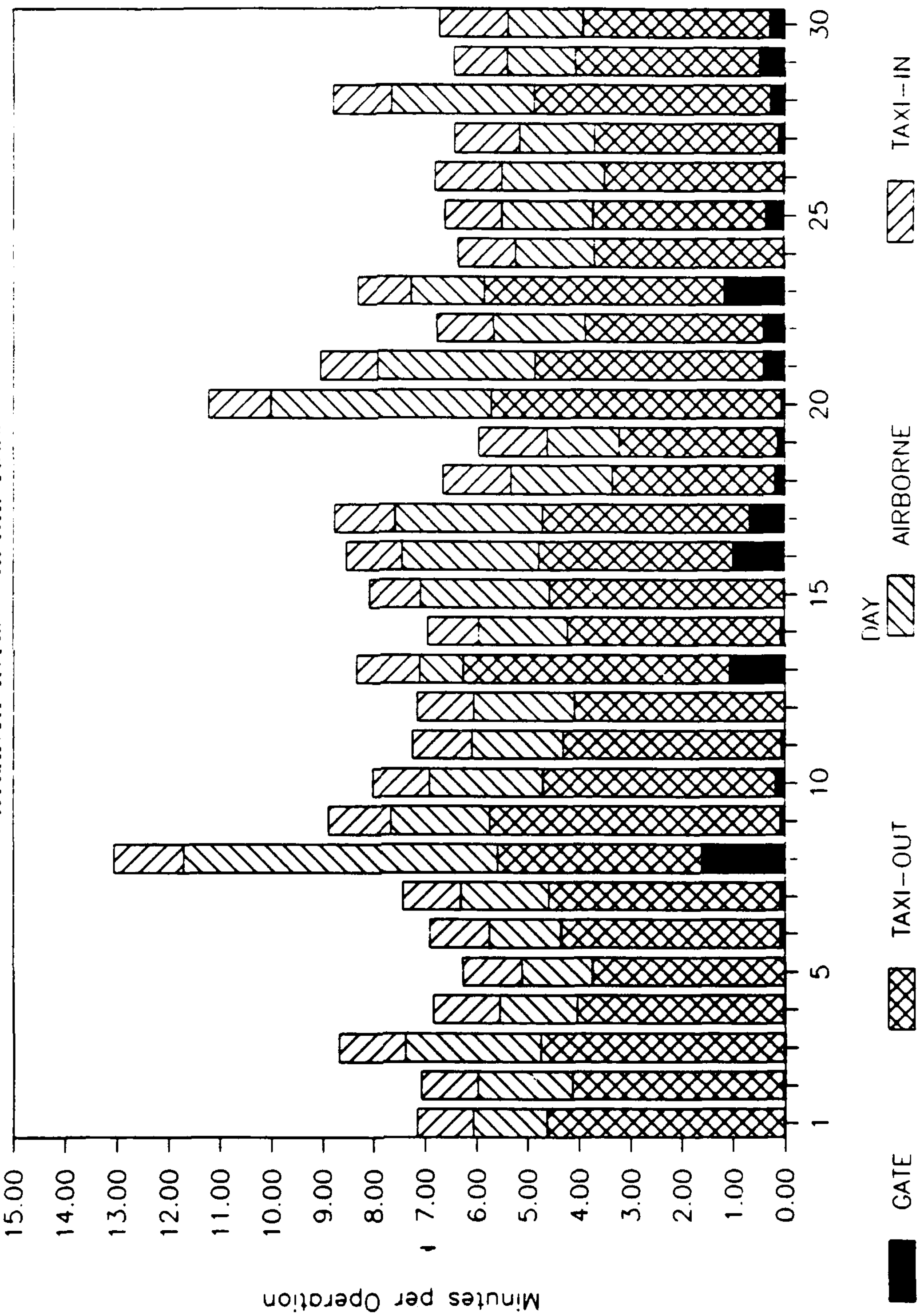
Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

Source: Standardized Delay Reporting System
NOTE: These statistics are based on average delay each day.

FIGURE II-2

AVERAGE DELAY BY DAY

ATLANTA INTL. - APRIL 1986



Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

TABLE II-4
DISTRIBUTION OF DELAY DURATION
(Percent of flights delayed in each phase of flight)
Total SDRS System - 1986

Flight phase	0 mins.	1-14 mins.	15-29 mins.	30-59 mins.	60+ mins	Total
Gate-hold	93.4	4.1	1.5	0.7	0.3	100
Taxi-out	7.4	80.5	10.2	1.6	0.3	100
Airborne	38.5	57.0	3.5	0.8	0.1	100
Taxi-in	16.1	81.1	2.2	0.5	0.1	100
Total flight	N/A	N/A	17.4	3.7	0.7	N/A

SOURCE: Standardized Delay Reporting System

NOTES:

1. Based on 1,576,437 flights performed by three major airlines in 1986.

2. The percent of total flights delayed in each time interval of 15 minutes or more is approximately equal to (but probably not greater than) the sum of the percent delayed in each of the four phases of flight for delays over 15 minutes. Because delays of less time in a number of phases could aggregate to a total of 15 minutes or more, this sum probably understates the actual percent of flights delayed 15 minutes or more.

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

This table also estimates the percentage of flights delayed by the amounts of time for the flight as a whole. For example, 17.4 percent of all SDRS flights (or 8.7 percent of all operations) were delayed between 15 and 29 minutes, and 0.7 percent were delayed an hour or more. Summing up the totals for the three increments of delay of 15 minutes or more, it is found that 21.8 percent of all flights (or 11 percent of all operations) were delayed 15 minutes or more.

Note that these figures were obtained by summing the percent of flights delayed in each flight phase for delays of 15 minutes or more. This assumes that the same flight was not delayed more than 15 minutes on more than one segment (a "serious" delay). Because the probability of a serious delay on any one phase is relatively small and the nature of the process tends to take the bulk of delay on one or another phase of flight only, this is a reasonable assumption for delays of 15 minutes or more. (It would not be a valid assumption for delays of smaller duration.) The estimate procedure does not account for the possibility that small delays on more than one segment could add up to a seriously delayed flight. Thus, this approximation probably slightly underestimates the percent of flights seriously delayed.

As is the case with average delay, the number of flights seriously delayed also varies considerably from day-to-day. Table II-5 displays the percent of operations delayed 15 minutes or more for the same airports listed in Table II-3. The airports that had the greatest variation in average delay also had significant variation in percent of operations delayed. This includes Boston, Dallas/Ft. Worth, Kennedy, LaGuardia, Newark, and Chicago airports. Incidentally, the days during which the maximum percent delayed occurred was usually the same day as that of the maximum average delay of Table II-3. However, this was not always the case.

Figure II-3 shows the percent of flight phases delayed 15 minutes or more each day at Atlanta International for April 1986. Each bar represents the percent of operations delayed 15 minutes or more. These percentages range from 4.4 percent on April 19 to 26.4 percent on April 20. It is interesting to note that these maximum and minimum days do not both correspond to the days of maximum and minimum average delay shown in Figure II-2. However, days which have high average delay tend to have a high percentage of "seriously delayed" flights.1/

Comparison of Figures II-2 and II-3 reveals that taxi-in delay is a larger portion of average delay than percent of serious delay. Taxi-in delay is relatively constant, ever-present, but seldom serious. On the other hand, gate-hold delay constitutes a relatively large share of serious delay. It is nonexistent for the great majority of flights, but when it occurs, it averages more than 30 minutes per flight. Thus, it does not contribute much to the average delay but it does contribute heavily to the delay of seriously delayed flights.

1/ The Spearman rank order correlation coefficient in this example is 0.92, which is significant at the 0.01 level. The fact that it is not 1.00 suggests that the shape of the distribution varies somewhat from day-to-day.

TABLE II-5

VARIATION IN OPERATIONS DELAYED - APRIL 1986

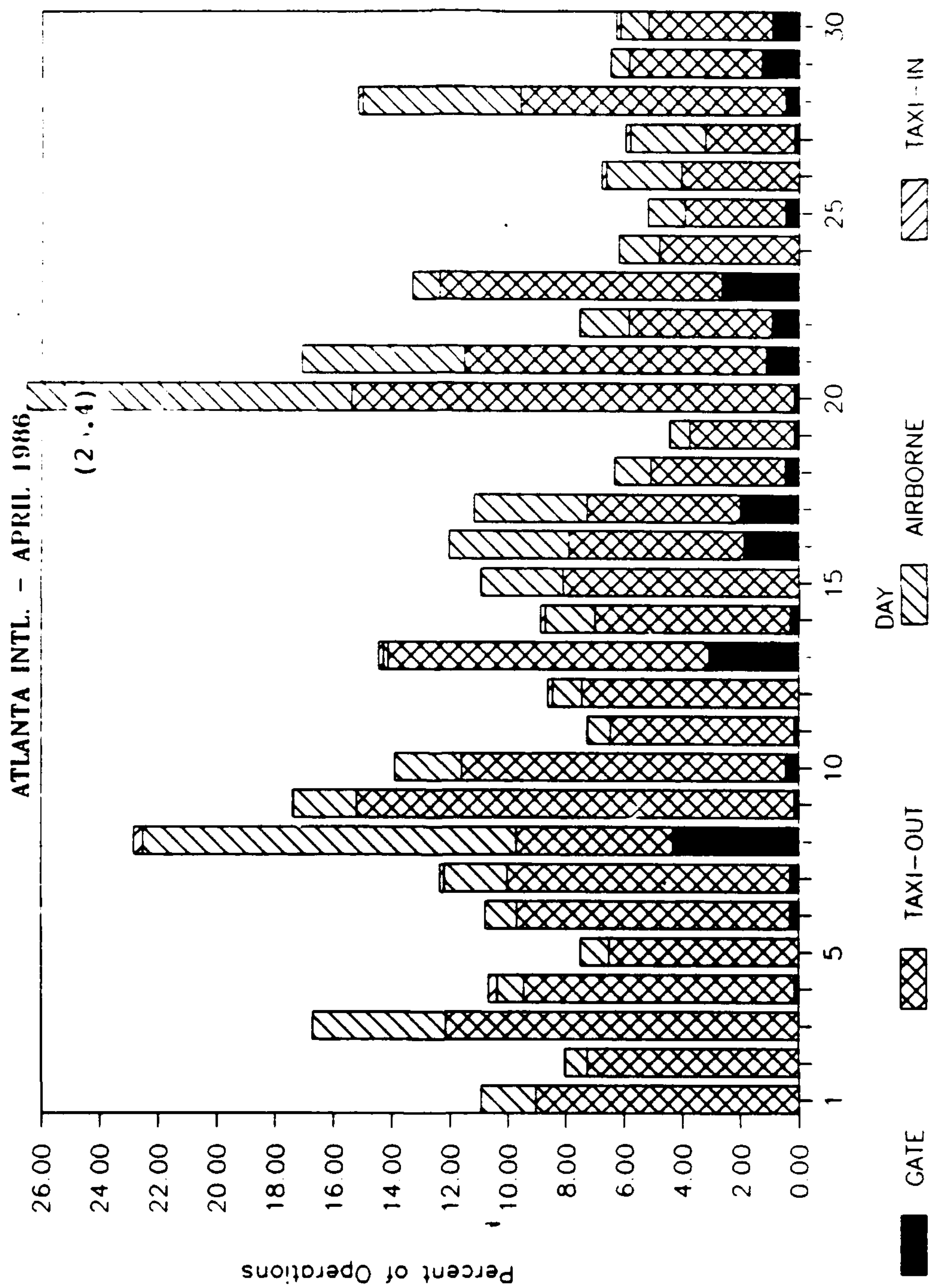
	Percent of Operations Delayed 15 Mins. or More			
LOCID	Average	Min. Day	Max. Day	Std. Dev.
ATL	11.1	4.4	26.4	4.9
BDL	2.0	0.0	20.0	5.2
BOS	16.5	2.8	55.6	13.0
BWI	6.2	0.0	18.8	4.5
CLE	2.4	0.0	5.7	1.6
CMH	0.2	0.0	7.1	1.3
CVG	1.5	0.0	8.3	2.6
DCA	10.9	0.0	43.4	9.2
DEN	17.6	3.5	37.8	8.6
DFW	21.3	13.0	53.6	8.2
DTW	6.4	0.0	15.1	3.7
EWR	19.3	5.2	59.5	19.3
HNL	11.3	1.9	24.0	5.7
IAD	5.0	0.0	13.5	3.9
IAH	2.2	0.0	14.4	3.1
IND	1.5	0.0	7.7	2.1
JAX	0.7	0.0	3.6	1.1
JFK	19.9	2.9	48.8	10.5
LAS	2.0	0.0	13.3	3.0
LAX	12.9	5.1	27.3	4.9
LGA	21.5	2.6	60.2	14.0
MCI	4.6	0.0	11.1	3.0
MCO	3.3	0.0	22.2	5.6
MEM	5.0	0.0	13.9	4.1
MIA	8.8	3.3	13.7	2.2
MSP	7.4	0.0	21.7	4.8
MSY	2.3	0.0	15.6	3.2
OAK	5.0	0.0	16.7	5.3
ONT	5.5	0.0	23.8	5.3
ORD	15.4	7.1	40.7	7.0
PDX	1.9	0.0	8.9	2.4
PHL	9.5	0.8	35.9	8.1
PHX	4.9	1.1	10.9	2.7
PIT	4.7	0.0	14.8	3.8
RDU	2.1	0.0	10.0	2.7
SAN	1.9	0.0	9.4	2.8
SEA	3.2	0.0	8.2	2.0
SFO	16.6	7.7	34.1	6.4
SJC	4.3	0.0	14.3	4.8
SMF	0.3	0.0	9.1	1.6
STL	8.6	0.0	24.0	4.7
TPA	1.2	0.0	4.2	1.2

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

Source: Standardized Delay Reporting System

NOTE: These statistics are based on the percent of SDRS operations reported delayed 15 minutes or more each day.

FIGURE II-3
FLIGHTS DELAYED 15 MINS. OR MORE



Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

Table II-6 presents the percent of flights delayed 15 minutes or more during each phase of flight for 55 selected airports in 1986. For example, of the 127,609 SDRS flights at ATL, 15,053 (11.8 percent, as shown) were delayed 15 minutes or more during the airborne phase and 381 (0.3 percent, as shown) were delayed 15 minutes or more during taxi-in. The percent of all arrival operations delayed 15 minutes or more was computed by summing the operations delayed during the airborne and taxi-in phases and dividing by the total SDRS arrival operations (to obtain 12.1 percent for ATL)[1]. Similar computations were performed for departure operations and total operations (which is the average of arrival and departure operations).

The highest incidence of serious delay for either arrivals or departures is departures from LaGuardia Airport (37 percent seriously delayed). Only 5.1 percent of LaGuardia (LGA) arrivals were seriously delayed (15 minutes or more). (This probably reflects that LGA arrivals are held at origin airports when problems at LGA develop.) Similarly, at most airports, departures are more likely to be delayed than arrivals. Exceptions are Dallas/Ft. Worth and Oakland. Overall (total system), 14.6 percent of all departures, 7.2 percent of all arrivals and 10.9 percent of all operations were seriously delayed.

Table II-7 presents the percent of SDRS operations delayed 15, 30, and 60 minutes or more, the number of SDRS operations, and the average delay per operation at 55 selected air carrier airports. For example, based on over 255,000 operations at ATL, 15.4 percent were delayed 15 minutes or more, 2.7 percent were delayed 30 minutes or more, and 0.4 percent were delayed 60 minutes or more. The average was 9.1 minutes of delay per operation. The airport with the most serious delay problem in 1986, both in terms of average delay and the percent of flights seriously delayed, was Newark International (EWR).

Figure II-4 shows the percent of operations seriously delayed for selected years between 1976 and 1986. The percent of operations delayed 15 minutes or more has more than doubled over that period.

Relationship Between Average Delay and Serious Delay

The relationship between average delay and percent of operations seriously delayed is demonstrated for 50 airports in Figure II-5. This chart indicates that airports that have a larger delay average tend to have a higher percentage of operations seriously delayed, as one might expect. This graph is based on 1985 data, but the relationship is not expected to change appreciably from year-to-year.

This chart shows, for example, that when average delay is about 7.6 minutes per operation, about 11 percent of all operations are delayed

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1/ This assumes that the same flight will not be delayed more than 15 minutes on both stages, and that other flights were not delayed enough on both segments to total 15 minutes or more.

TABLE II-6

DELAY OF 15 MINUTES OR MORE - 1986

LOCID	Percent of Flights--By Phase of Flight				Percent of Operations		
	Gate-hold	Taxi-out	Airborne	Taxi-in	Depart	Arrive	Overall
ATL	1.2	17.4	11.8	0.3	18.6	12.1	15.4
BDL	2.8	5.5	1.3	0.4	8.3	1.7	5.0
BOS	6.2	12.8	8.3	0.4	19.0	8.8	13.9
BWI	3.7	6.6	2.1	0.2	10.4	2.3	6.3
CHS	3.6	1.4	0.5	0.1	5.0	0.6	2.8
CLE	3.8	2.1	1.1	0.1	5.9	1.2	3.5
CLT	3.9	6.5	1.7	0.5	10.4	2.2	6.3
CMH	3.5	2.1	0.8	0.2	5.7	1.0	3.4
CVG	2.2	1.4	1.4	0.1	3.6	1.5	2.6
DCA	2.7	18.9	2.5	0.3	21.6	2.9	12.2
DEN	1.0	20.8	4.5	3.8	21.8	8.3	15.1
DFW	1.1	13.7	7.1	9.1	14.8	16.2	15.5
DTW	2.9	5.2	4.1	0.2	8.1	4.4	6.2
EWR	8.7	26.8	9.1	0.4	35.6	9.5	22.5
FLL	2.7	3.3	1.4	0.7	6.0	2.0	4.0
HNL	0.7	5.8	4.9	0.5	6.4	5.4	5.9
IAD	2.1	15.0	1.9	0.6	17.2	2.5	9.9
IAH	2.4	2.1	2.0	0.1	4.6	2.1	3.3
IND	3.5	1.8	1.7	0.4	5.3	2.0	3.7
JAX	3.6	0.7	0.6	0.0	4.3	0.7	2.5
JFK	2.1	23.2	5.8	2.4	25.3	8.2	16.8
LAS	2.2	2.9	2.8	0.1	5.1	2.9	4.0
LAX	4.7	13.8	4.0	1.3	18.5	5.3	11.9
LGA	1.8	35.6	3.6	1.6	37.4	5.1	21.3
MCI	7.1	5.2	0.8	0.1	12.3	0.8	6.6
MCO	2.8	3.8	1.0	0.1	6.7	1.1	3.9
MEM	1.7	4.7	2.1	0.2	6.4	2.3	4.3
MIA	3.5	15.2	2.3	0.8	18.7	3.1	10.9
MKE	2.3	3.5	1.7	0.5	5.9	2.1	4.0
MSP	5.1	5.9	6.9	0.5	11.0	7.4	9.2
MSY	2.0	1.1	1.0	0.4	3.2	1.4	2.3
OAK	3.3	3.8	5.5	1.1	7.1	6.5	6.8
ONT	4.0	7.1	3.9	0.1	11.1	4.0	7.5
ORD	0.7	20.3	5.5	11.1	21.0	16.7	18.9
PBI	3.9	3.5	0.8	0.5	7.4	1.3	4.3
PDX	2.2	1.1	2.0	0.3	3.3	2.3	2.8
PHL	2.7	11.6	5.0	0.5	14.2	5.6	9.9
PHX	2.7	4.5	2.2	0.2	7.2	2.4	4.8
PIT	4.2	6.3	1.9	0.1	10.5	2.0	6.2
PVD	2.5	1.8	1.0	0.3	4.2	1.2	2.7
RDU	3.7	1.2	1.0	0.2	4.9	1.2	3.0
RIC	6.3	0.9	1.1	0.0	7.1	1.1	4.1
SAN	2.9	5.4	3.6	0.2	8.3	3.8	6.0
SAT	1.6	1.9	2.2	0.1	3.6	2.3	2.9
SEA	2.0	2.0	3.2	0.1	4.1	3.3	3.7
SFO	4.3	19.1	6.9	2.3	23.4	9.2	16.3
SJC	2.9	5.0	3.1	0.2	7.9	3.3	5.6
SLC	2.7	4.6	2.3	0.1	7.3	2.4	4.8
SMF	2.6	1.5	1.5	0.4	4.1	2.0	3.0
SRQ	4.7	1.2	0.7	0.0	5.9	0.7	3.3
STL	3.1	15.8	6.7	0.2	18.9	6.9	12.9
SYR	4.5	6.4	1.4	0.2	10.9	1.6	6.2
TPA	1.9	1.8	1.0	0.1	3.7	1.2	2.4
TUL	3.6	3.4	4.3	0.3	7.0	4.5	5.8
TUS	2.2	1.9	2.3	0.0	4.1	2.3	3.2
SYSTEM	2.5	12.1	4.4	2.8	14.6	7.2	10.9

NOTE: "System" refers to operations at all domestic airports.

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

Source: Standardized Delay Reporting System

TABLE II-7

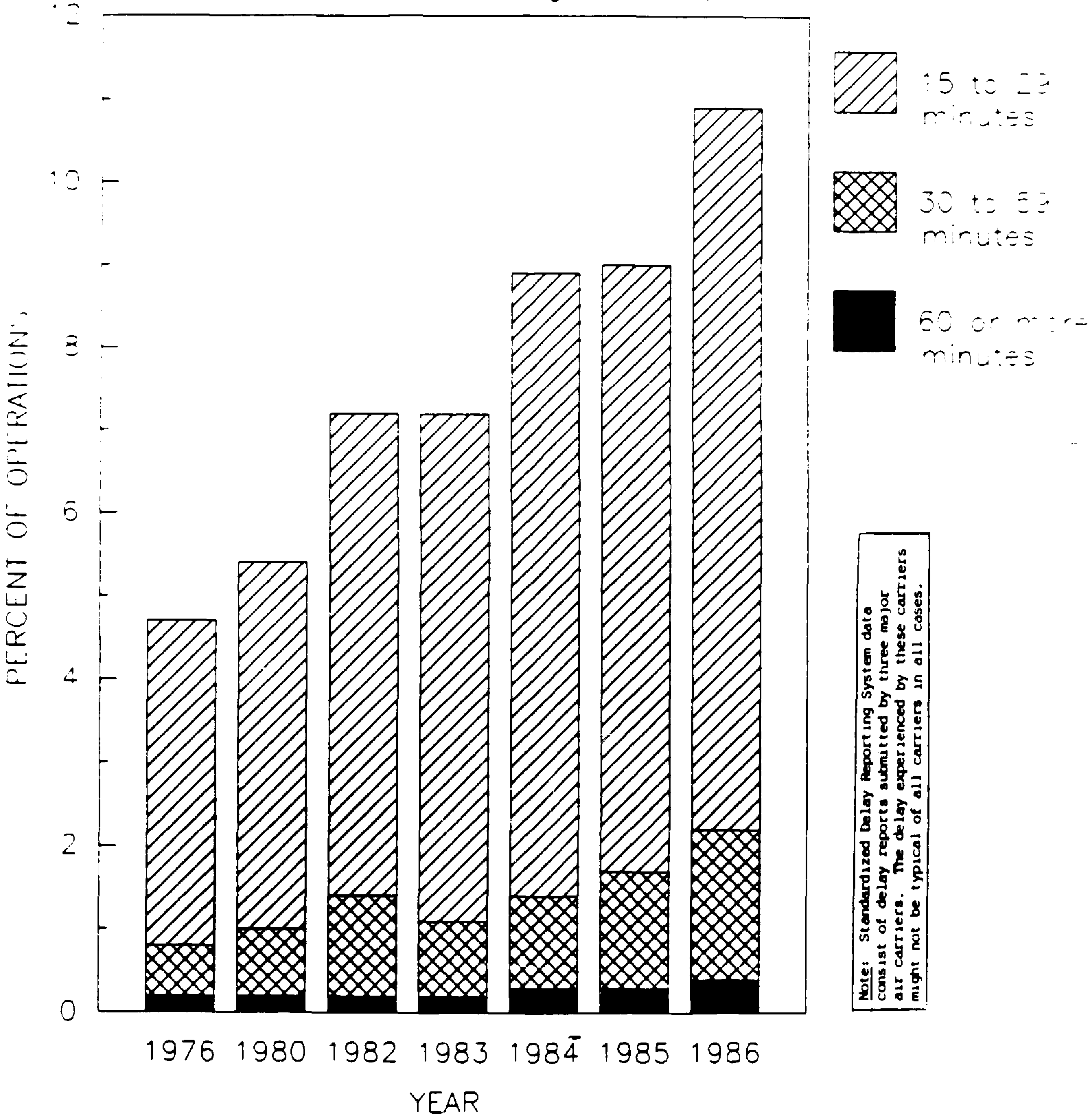
PERCENT OF OPERATIONS DELAYED - By Airport - 1986

LOCID	Percent Delayed at Least: 15 mins.	30 mins.	60 mins.	No. of SDRS Ops. (000)	Avg. Dly. Mins./Op.
ATL	15.4	2.7	0.4	255.2	9.1
BDL	5.0	1.0	0.3	20.6	6.2
BOS	13.9	2.8	0.5	57.8	9.0
BWI	6.3	1.5	0.3	23.9	5.1
CHS	2.8	1.1	0.2	14.2	4.9
CLE	3.5	0.9	0.2	39.4	5.1
CLT	6.3	1.2	0.3	38.6	6.6
CMH	3.4	0.8	0.2	17.6	5.2
CVG	2.6	0.7	0.3	10.1	3.9
DCA	12.2	2.9	0.6	58.2	7.7
DEN	15.1	2.3	0.2	159.7	8.6
DFW	15.5	2.6	0.4	244.2	9.6
DTW	6.2	1.4	0.4	29.4	6.5
EWR	22.5	5.3	0.9	48.4	11.9
FLL	4.0	0.9	0.2	32.3	5.3
HNL	5.9	0.9	0.0	18.4	7.1
IAD	9.9	1.8	0.5	46.2	8.1
IAH	3.3	0.8	0.2	35.3	4.8
IND	3.7	1.1	0.3	18.9	4.5
JAX	2.5	0.8	0.2	18.0	4.5
JFK	16.8	4.2	0.7	46.6	9.9
LAS	4.0	0.7	0.1	19.8	4.4
LAX	11.9	1.9	0.3	85.5	8.6
LGA	21.3	4.6	0.5	96.4	10.3
MCI	6.6	1.6	0.3	13.1	6.5
MCO	3.9	1.0	0.3	40.5	5.2
MEM	4.3	0.9	0.2	10.9	5.1
MIA	10.9	1.8	0.5	86.0	7.7
MKE	4.0	1.4	0.5	12.0	5.3
MSP	9.2	2.3	0.5	16.2	6.4
MSY	2.3	0.7	0.2	19.9	3.7
OAK	6.8	1.1	0.1	11.2	5.8
ONT	7.5	1.2	0.1	15.9	6.7
ORD	18.9	4.4	0.7	417.3	10.8
PBI	4.3	1.1	0.3	14.3	5.5
PDX	2.8	0.6	0.1	24.2	4.9
PHL	9.9	2.1	0.4	47.8	7.0
PHX	4.8	0.8	0.2	31.3	5.9
PIT	6.2	1.1	0.3	20.3	5.9
PVD	2.7	0.7	0.2	10.6	4.4
RDU	3.0	0.9	0.3	20.4	4.9
RIC	4.1	1.3	0.4	10.6	5.0
SAN	6.0	0.8	0.1	22.2	5.9
SAT	2.9	0.8	0.2	16.5	5.2
SEA	3.7	0.7	0.1	44.7	5.0
SFO	16.3	2.3	0.2	116.5	9.3
SJC	5.6	0.7	0.2	12.0	7.1
SLC	4.8	1.0	0.3	12.9	6.1
SMF	3.0	0.8	0.1	14.1	4.0
SRQ	3.3	1.4	0.3	8.8	4.5
STL	12.9	2.6	0.4	18.1	7.9
SYR	6.2	1.2	0.3	9.2	6.2
TPA	2.4	0.7	0.2	41.0	4.5
TUL	5.8	2.3	0.6	15.6	5.7
TUS	3.2	0.5	0.1	10.7	3.8
SYSTEM	10.9	2.2	0.4	3,148.9	7.6

Note: Standardized Delay Reporting System data consist of delay reports submitted by three major air carriers. The delay experienced by these carriers might not be typical of all carriers in all cases.

SOURCE: Standardized Delay Reporting System

FIGURE II-4
PERCENT OF OPERATIONS DELAYED
15, 30, OR 60 MINUTES OR MORE
(Total SDRS System)

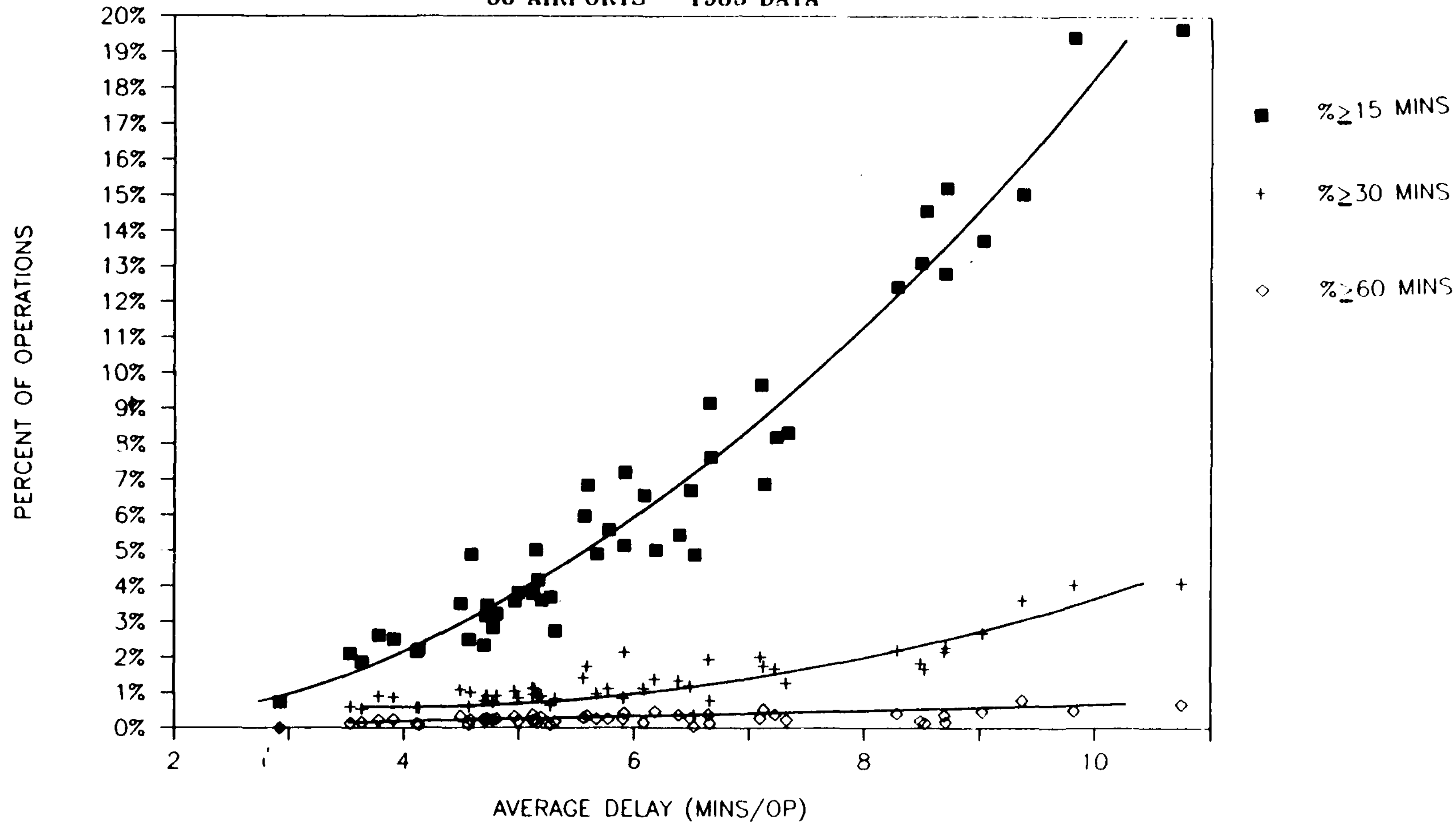


Source: Standardized Delay Reporting System

FIGURE II-5

SERIOUS DELAY VS AVERAGE DELAY/OPERATION

50 AIRPORTS - 1985 DATA



15 minutes or more (as is the case for 1986). However, if average delay becomes 10 minutes per operation, then about 18 percent of all operations will be seriously delayed.

The next section discusses the costs of delay.

SECTION III

DELAY IMPACTS

The SDRS collects data on the impact of aircraft delay on: direct operating cost, gallons of fuel consumed, and hours of passenger delay.

DIRECT OPERATING COST

Direct operating costs, reported in SDRS, are based on Form 41 data, submitted by the carriers to the Research and Special Programs Administration. Form 41 data are used to derive unit hourly costs for each equipment type each quarter. Direct operating cost includes the cost of fuel and oil, direct maintenance, and cockpit and cabin crew. It does not include maintenance burden, training, or investment costs. Delay cost is the sum of the hours of delay for each equipment type times the unit cost for that equipment type and that airline. Different hourly costs are incurred for taxiway and airborne delay. No operating cost is charged against ATC gate-hold delay in the SDRS, but an estimate of this cost is included in this Section.

FUEL CONSUMPTION

Fuel consumption is the sum of unit fuel consumption per hour (for each equipment type) times the hours of delay for the equipment type. Different unit consumptions are used for taxiway versus airborne delay. No fuel consumption is charged against ATC gate-hold delay.

PASSENGER DELAY

Passenger delay is the number of revenue passengers on the aircraft times the hours of delay for all delayed flights (on any phase of flight). This considers only the passenger delay that occurs after the passengers are boarded and the aircraft is ready to depart. It does not include delays that cause the aircraft to operate behind schedule such as the previous segment arriving late, aircraft equipment problems, waiting for connecting passengers, etc.

Thus, the passenger's perception of the amount of delay could be much larger than the delay computed here. On the other hand, airline schedules anticipate a certain amount of delay, and the passenger would probably only perceive delay to the extent that the flight arrives behind schedule. Therefore, the passenger would probably not perceive some of the delay that is computed in this analysis.

IMPACT TRENDS

Table III-1 compares 1976, 1985, and 1986 delay costs for the three carriers reporting under the SDRS system. This table represents the SDRS data used to develop several analyses discussed later in this Section. The 1976 impacts are based on 1.4 million flights and 1986 impacts on 1.6 million flights performed by SDRS carriers. The impact on direct operating cost is expressed in current year dollars.

TABLE III-1
COMPARISON OF SDRS DELAY COSTS - 1976, 1985 and 1986
(all costs in current year dollars)

	1976	1985	1986
Number of flights (000)	1,419	1,387	1,576
Hours of delay:			
ATC gate-hold	1,464	23,816	29,490
Taxi-out	105,396	152,511	193,091
Airborne	101,129	80,313	93,965
Taxi-in	51,002	62,688	80,124
Total	258,991	319,327	396,670
Direct operating cost ($000)			
Taxi-out	79,708	211,150	270,983
Airborne	101,621	182,621	214,496
Taxi-in	39,593	87,108	113,515
Fuel consumption gals. (000)			
ATC gate-hold	0	0	0
Taxi-out	53,650	68,865	86,491
Airborne	148,049	120,704	140,587
Taxi-in	26,755	28,231	35,533
Total	228,455	217,800	262,611
Passenger hours (000)	17,203	31,176	39,707

SOURCE: Standardized Delay Reporting System

NOTES:

1. Direct operating cost includes the cost of crew, fuel and oil and direct maintenance only (based on Form 41 data).

2. No cost is shown for ATC gate-hold delay because these are not computed in the SDRS. An estimate of these costs is included later in this report.

3. Passenger hours is the product of delay hours times the number of revenue passengers on board.

The average cost for an hour of delay has varied over the last 11 years (see Table III-2). For example, the average hour of taxi-out and taxi-in delay cost $763 in 1976 and $1,407 in 1986, the average hour of airborne delay cost $1,005 in 1976 and $2,283 in 1986, and the average cost of an hour of delay overall increased from $855 to $1,554. However, when the overall hourly cost is adjusted for inflation, the 1986 cost was actually almost equal to the 1976 cost, and less than in all intervening years except for 1979 and 1980. Per hour costs in real terms reached a high in 1982 that was 21 percent greater than it was in 1986.

Table III-2 indicates that fuel consumption per hour of delay decreased over the 1976 through 1986 period. This is, at least partly due to the reduction in the proportion of delay taken in the air.

Table III-3 demonstrates the effect of a reduction in the percent of delay taken in the air. The average cost for an hour of delay in 1976, 1985, and 1986 for each phase is shown in 1986 dollars. Comparing 1976 and 1986 costs, the cost per hour of airborne delay increased 25.2 percent in constant dollars, while ground delay costs increased only slightly. However, overall delay cost (which is a weighted average based on the number of hours in each phase) actually decreased. This suggests that the shift in the reduction in the percent of delay taken in the air overcame a significant increase in airborne operating cost. Comparing 1985 and 1986, the overall hourly operating cost declined by 1.7 percent which exceeded the decline in hourly cost for all phases, reflecting a decrease in the percent of delay taken in the air. (The portion of delay taken in the air was 39 percent in 1976, 25 percent in 1985, and 24 percent in 1986.)

Table III-3 also indicates that between 1976 and 1986, the fleet mix of aircraft became more fuel efficient on the ground and slightly less fuel efficient in the air. The combined effects of greater efficiency on the taxiway, where 69 percent of delay now occurs, and the decrease in the percent of delay taken in the air, resulted in a 25 percent decrease in fuel consumption per hour of delay.

Table III-4 contains total delay cost for the three SDRS carriers and their passengers for 1976, 1985, and 1986, in constant 1986 dollars. The total SDRS delay cost is $1.5 billion for 1986, a 92 percent increase over 1976, and a 25 percent increase over 1985. Note that in 1976, passenger delay cost ($389 million) was slightly less than operating cost ($402 million), but in 1985 and 1986 passenger delay cost ($902 million in 1986) was significantly larger than operating cost ($617 million). Operating cost per hour decreased slightly and the value of passenger time remained constant (in terms of constant dollars), but the number of passengers on each flight increased significantly.

ESTIMATED COST IMPACT FOR ALL AIR CARRIERS

The SDRS data were used to estimate the total cost of delay for all scheduled air carriers, as shown in Table III-5. It is assumed that delay for all air carriers, on average, is approximately equal to the delay experienced by the SDRS carriers. However, the number of passengers on board the typical air carrier aircraft is likely to be considerably smaller than the SDRS average, and the operating costs could be somewhat

TABLE III-2
COST PER HOUR OF DELAY
(SDRS Carriers - Total System)

Year	Direct Operating Cost (current $) -------- Phase of Flight --------- ATC hold	Taxiway	Airborne	Overall	Overall Cost in 1986 $	Fuel in Gallons per hour	Passengers Delayed per flight
1976	$320	$763	$1,005	$855	$1,547	882	66
1977	354	844	1,156	958	1,629	870	76
1978	356	847	1,204	976	1,541	866	n/a
1979	381	908	1,301	1,045	1,515	856	n/a
1980	484	1,152	1,847	1,385	1,842	837	n/a
1981	553	1,316	2,181	1,508	1,824	766	n/a
1982	639	1,522	2,442	1,653	1,884	658	n/a
1983	597	1,421	2,356	1,666	1,833	741	101
1984	595	1,416	2,272	1,626	1,723	720	96
1985	582	1,386	2,274	1,550	1,581	682	98
1986	591	1,407	2,283	1,554	1,554	662	100

SOURCE: Standardized Delay Reporting System

NOTES:

1. Direct operating cost includes crew, fuel and oil, and direct maintenance costs (based on Form 41 data) in current year dollars. This was obtained from data in Table III-1 by dividing total cost by hours of delay. Direct operating cost for ATC gate-hold delay was estimated by taking 42 percent of taxiway cost (a relationship based on currently-available data).

2. Overall cost in 1986 dollars is overall average cost adjusted for inflation to constant 1986 dollars using the GNP implicit price deflator.

3. Fuel is fleet average fuel consumption (based on Form 41 data), weighted by delay experienced.

4. Passengers per flight is a delay-weighted average number of revenue passengers on board each aircraft. These data are not available for 1978 through 1982.

TABLE III-3
HOURLY OPERATING COST AND FUEL CONSUMPTION
(SDRS TOTAL SYSTEM)

	1976	1985	1986	Percent Change 85-86	76-86
Percent of Delay by Phase of flight					
ATC gate-hold	0.6	7.4	7.4	0.0	1,133
Taxi-out	40.7	47.8	48.7	1.9	19.7
Airborne	39.0	25.2	23.7	-6.0	-39.2
Taxi-in	19.7	19.6	20.2	3.1	2.5
Direct Operating Cost (1986 dollars/hour)					
ATC gate-hold	579	594	591	-0.5	1.0
Taxi-out	$1,368	$1,412	$1,403	-0.6	2.6
Airborne	1,819	2,319	2,283	-1.6	25.5
Taxi-in	1,404	1,417	1,417	0.0	0.6
Overall	1,547	1,581	1,554	-1.7	0.9
Fuel Consumption (gals./hour)					
Taxi-out	509	451	443	-1.8	-3.0
Airborne	1,464	1,503	1,496	-0.5	2.2
Taxi-in	524	450	448	-0.4	-14.5
Overall	882	682	662	-2.9	-24.9

SOURCE: Standardized Delay Reporting System

NOTES:

1. Overall cost and fuel consumption are weighted averages over all four phases of flight for the equipment used by the three SDRS carriers. These costs might not be typical of all air carriers.

2. Different hourly cost and fuel consumption values for taxi-in and taxi-out delay are the result of a slight difference in the mix of aircraft experiencing the delay.

TABLE III-4
COMPUTATION OF TOTAL SDRS DELAY COST
(1986 Dollars)

Item	1976	1985	1986
1. Hours of delay per flight	0.183	0.230	0.252
2. No. of revenue flights (thousands)	1,419	1,387	1,576
3. Total delay (thousands of hours) (1x2)	260	319	397
4. Aircraft operating cost ($/delay hour)	1,547	1,581	1,554
5. Total operating cost ($millions)(3x4/1000)	402	504	617
6. Revenue passengers/flight	66	98	100
7. Passenger delay (million pass. hrs.) (3x6)	17.1	31.3	39.7
8. Value of passenger time ($/passenger hour)	22.70	22.70	22.70
9. Total passenger delay cost ($millions) (7x8)	389	710	902
10. Total delay cost ($ millions) (5+9)	791	1,214	1,519

SOURCE: Standardized Delay Reporting System

NOTES:

1. Line 1 is the average hours of delay per flight.

2. Line 2 is the number of SDRS flights for the year.

3. Line 3 is a computed value of the total delay obtained by multiplying Line 1 and Line 2.

4. Line 4 contains the average operating cost per hour of delay (weighted by the mix of aircraft and phase of flight where the delay was taken).

5. Line 5 is the product of Line 3 and Line 4, which is the total operating cost impact of delay on the SDRS carriers.

6. Line 6 is the average number of revenue passengers on board while the aircraft was delayed.

7. Line 7 is the total passenger delay in millions of passenger hours, obtained by multiplying Line 3 and Line 6 and dividing by 1,000.

8. Line 8 is the estimated value of passenger time, as derived by the Office of Aviation Policy and Plans for use in economic analyses.

9. Line 9 is the total cost impact of delay on SDRS carrier passengers obtained by multiplying Line 7 by Line 8.

10. Line 10 is the sum of Lines 5 and 9. (Note that the sums may not appear to be correct, but this is due to rounding.)

less for the average air carrier aircraft than the SDRS aircraft, due both to the use of smaller aircraft (on average) and lower wage scales.

The airborne operating cost reported by major, national, and regional carriers on Form 41 for 1984 averaged $1,671 per hour (weighted by airborne hours flown for each equipment type). A similar computation for the three SDRS carriers produced an average of $1,877 per hour. This implies that the average Form 41 carrier delay cost per hour is 89 percent of the SDRS average.

In order to make a conservative estimate for all carriers, it was assumed that the operating cost for the average air carrier aircraft is 75 percent of the average operating cost for the SDRS aircraft. This is the assumption used to obtain the numbers on Line 4 of Table III-5. The result is an estimate of $977 million (1986 dollars) in 1976 and $1.8 billion in 1986. The 1986 operating cost is 86 percent greater than 1976 and 17 percent larger than 1985 (in constant dollars). This is larger than the increase for the SDRS carriers (Table III-4) because there was a larger increase in total air carrier operations than in SDRS operations (34 percent versus 11 percent between 1976 and 1986).

The total cost of passenger delay was $1.4 billion in 1976, $2.8 billion in 1985, and 3.3 billion in 1986 (all in 1986 dollars). This represents a 131 percent increase (in constant dollars) between 1976 and 1986 due to a combination of a 25 percent increase in the number of passengers per aircraft, a 38 percent increase in delay per flight, and a 34 percent increase in the number of flights. The 19 percent increase in passenger delay cost between 1985 and 1986 is the result of a 10 percent increase in average delay and an 8 percent increase in the number of flights.

The total combined operating cost and passenger delay cost is estimated to be $2.4 billion in 1976, $4.3 billion in 1985, and $5.1 billion in 1986. This is an increase of 113 percent between 1986 and 1976, and of 20 percent between 1985 and 1986. The increase is due to a combination of more delay per flight, more flights, and more passengers on each flight.

SAVINGS RESULTING FROM FAA FLOW CONTROL

This section estimates the savings derived from the increased use of FAA flow control procedures, which were in their infancy in 1976. Table III-6 develops comparative cost and fuel consumption rates for 1986 under two alternative hypotheses: 1) that the 1986 delay was distributed as it had been in 1976, corresponding to the degree that flow control was used at that time, and 2) that the 1986 delay was distributed as reported, corresponding to the improvement in managing air traffic in 1986.

These comparisons depend on differences between 1976 and 1986 in the percent of all delay by phase of flight, as shown in Table III-3. The significant increases in the percent of delay taken in ATC gate hold and taxi-out phases of flight, as well as the 39 percent reduction in the share of delay taken in the airborne phase may be attributed to the increased use of flow control and are circumstantial evidence of the impact of flow management in reducing delay cost.

TABLE III-5
COMPUTATION OF TOTAL DELAY COST FOR ALL AIR CARRIERS
(1986 Dollars)

Item	1976	1985	1986
1. Hours of delay per flight	0.183	0.230	0.252
2. No. of revenue flights (thousands)	4,601	5,618	6,177
3. Total delay (thousands of hours) (1x2)	842	1,292	1,557
4. Aircraft operating cost ($/delay hour)	1,160	1,186	1,165
5. Total operating cost ($millions)(3x4/1000)	977	1,532	1,815
6. Revenue passengers/flight	74.5	92.6	93.1
7. Passenger delay (million pass. hrs.) (3x6)	62.7	119.7	144.9
8. Value of passenger time ($/passenger hour)	22.70	22.70	22.70
9. Total passenger delay cost ($mils.) (7x8)	1,424	2,716	3,290
10. Total delay cost ($ millions) (5+9)	2,401	4,248	5,105

NOTES:

1. Line 1 is the average delay reported through the Standardized Delay Reporting System.

2. Line 2 is obtained by taking the number of domestic air carrier revenue flights reported on Form 41 (Line 32 of Air Carrier Traffic Statistics).

3. Line 3 is Line 1 times Line 2. Total air carrier delay in thousands of hours.

4. Line 4 is obtained by taking 75 percent of the SDRS value (a conservative estimate).

5. Line 5 is Line 3 times Line 4 divided by 1,000. Total direct operating cost due to delay includes direct maintenance, crew, and fuel and oil, but no investment or overhead costs.

6. Line 6 is the average number of passengers per mile on domestic flights as reported on Form 41 (Line 33 of Air Carrier Traffic Statistics).

7. Line 7 is Line 3 times Line 6 divided by 1,000.

8. Line 8 is based on Economic Values for Evaluation of FAA Programs (FAA-APO-84-3).

9. Line 9 is Line 7 times Line 8. Total value of passenger time on delayed aircraft does not include passenger delay prior to aircraft ready to depart.

10. Line 5 plus Line 9, a total of aircraft operating and passenger delay cost.

11. Note that this only includes delay due to airport and airspace congestion; it does not include delay due to aircraft mechanical problems, etc.

In Part (a) of Table III-6, the average cost for an hour of delay in 1986 is computed under the two alternative situations. The cost per hour for each phase of flight is shown in the first column. This is the same as the costs shown in Table III-3. The cost of delay per hour under either situation is the sum of the cost of delay per hour for each phase times the fraction of delay time that occurs in each phase.

A similar computation was performed for the amount of fuel per delay hour in Part (b) of Table III-6. No such computation was made for passenger delay because the cost to the passenger is independent of the phase of flight.

Part (c) of Table III-6 indicates that an average cost of an hour of delay would have been $1,744 with the 1976 level of flow control compared to $1,554 with the 1986 level. This suggests that without flow control, delay costs would have been 12.2 percent greater. Based on $1.815 billion in direct operating cost for all air carriers in 1986 (Table III-5), this would have added $221 million in airline operating cost in 1986.

Part (c) also shows that fuel consumption would have averaged 852 gallons per hour without flow control compared to the actual 662 gallons per hour. This suggests that without improved flow control, delay-caused fuel consumption would have been 190 gallons per delay hour greater. However, this is based on consumption rates experienced by SDRS carriers. To be consistent with the conservative consumption that the average cost for Form 41 carriers is 75 percent of that for the SDRS carriers, a similar assumption is made for fuel consumption. This makes the saving 142.5 gallons per hour. Based on 1.557 million delay hours for all air carriers (Table III-5), an extra 142.5 gallons per hour would have added 222 million gallons of wasted fuel in 1986.

The analysis assumes that total delay would be the same with or without flow control; i.e., all that flow control does is to relocate, not reduce delay. In practice, flow control programs can also reduce delay by rerouting traffic around bottlenecks. Also, note that savings would accrue to airspace users other than Form 41 carriers. Thus, the computed savings are considered conservative estimates.

OTHER CONSIDERATIONS

This Section estimated the impacts of delay on airline operating cost, fuel consumption, and passenger delay The cost estimate is a projection of average hourly ramp-to-ramp direct operating cost on the time lost due to NAS delay. This is only a fraction of the cost to the carriers. When serious delay problems develop, delay can propagate throughout the system. Flight departures are held for connecting departures on late-arriving aircraft. (SDRS does not count this delay time because the airline requests a late departure.) Flight crews must sometimes be replaced when company and/or FAA flight time limits are exceeded

TABLE III-6

A COMPUTATION OF DELAY COST SAVING DUE TO FLOW CONTROL - 1986

(a) Direct operating cost per hour of delay in 1986 (dollars per hour)

Phase of flight	Cost (1986 $ / hour)	1976 flow control percent of total	1976 flow control weighted average	1986 flow control percent of total	1986 flow control weighted average
ATC Gate-hold	591	0.6	4	7.4	42
Taxi-out	1403	40.7	571	48.7	683
Airborne	2283	39.0	890	23.7	541
Taxi-in	1417	19.7	279	20.2	286
Total	- -	100.0	1744	100.0	1554

(b) Fuel consumption per hour of delay in 1986 (gallons per hour)

Phase of flight	Consumption in gals./hr	1976 flow control percent of total	1976 flow control weighted average	1986 flow control percent of total	1986 flow control weighted average
ATC Gate-hold	0	0.6	0	7.4	0
Taxi-out	448	40.7	182	48.7	218
Airborne	1496	39.0	583	23.7	355
Taxi-in	443	19.7	87	20.2	89
Total	- -	100.0	852	100.0	662

(c) **Results:**

	Operating cost (dollars/hour)	Fuel consumption (gallons/hour)
1986 flow control	1554	662
1976 flow control	1744	852
difference	- 12.2 percent	190 net

Total air carrier impact for 1986:

Operating cost = 0.122 x $1,815 million = $221 million
Fuel consumed = 190 x 0.75 x 1,557 = 222 million gallons

Ultimately, additional aircraft, gates, and personnel must be available. In extreme cases, flights must be cancelled or diverted, resulting in a revenue loss, and passenger compensation must be provided.

Likewise, passenger delay is a conservative estimate. It is a product of aircraft delay and the number of revenue passengers on board. It does not include passenger time lost prior to the crew reporting ready to depart.

Since the time these data were collected, a number of actions were taken to control delay. For example: 1) the FAA installed new equipment, including a more reliable ATC computer system, and instituted improved ATC procedures, such as restructured airspace along the crowded east coast of the United States, 2) top officials of the FAA met with the airlines to encourage them to reschedule flights where an unreasonable number of aircraft were scheduled to land and takeoff at the same airport simultaneously, and 3) the Office of the Secretary of Transportation began public reporting of scheduled versus actual flight times. The impact of these changes is not reflected in this report. Future analyses of SDRS data might yield data on how effective these measures have been.

SECTION IV

CONCLUSIONS

This report summarized air carrier delay and delay cost data obtained through the Standardized Delay Reporting System for 1976 through 1986. The delay covered in this system is that due to limitations in the National Airway System (NAS) such as inadequate runway, taxiway, and airspace capacity; adverse weather; NAS equipment problems; etc. It does not include delay due to aircraft equipment problems, airline operating problems, etc. Results are:

1. Delay per operation increased 38 percent between 1976 and 1986.

2. NAS delay added over 20 percent to the time required for the average domestic air carrier flight in 1986.

3. The percent of operations delayed 15 minutes or more doubled between 1976 and 1986.

4. An hour of delay cost the carriers about the same in 1986 as in 1976 (in constant dollars) and consumed less fuel.

5. In 1986 an estimated total of 145 million passenger hours were lost due to delay, a 131 percent increase over 1976.

6. NAS delay cost air carriers and their passengers $5.1 billion in direct operating cost and lost time in 1986, which is more than double the cost in 1976 (in constant dollars).

7. A major reason that delay cost was not greater was the increased use of FAA flow control procedures. FAA flow control procedures contributed to an estimated $221 million reduction in direct operating cost, including the cost of over 200 million gallons of fuel, in 1986.